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DETERMINATION OF SURFACE RADIATION DOSE-RATE IN THE ENVIRONMENT OF KELATAN STATE MALAYSIA

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Abstract. Measurements of environmental surface radiation dose rate in Kelantan state, Malaysia was carried out using a portable hand held radiation survey meter and Global Positioning System (GPS). The surface radiation dose rates ranged from 44 to 500 nGy h^{-1}. The measurements were done based on geology and soil types of the area. The mean radiation dose rate was found to be 209 ± 8 nGy h^{-1}. Few areas of relatively enhanced activity were located in Pasir Mas, Tanah Merah and Jeli districts which have external gamma dose rates between 300 to 500 nGy h^{-1}. An Isodose map of the state was produced using ArcGIS10 software version 10.1. To evaluate the radiological hazard due to terrestrial gamma dose, the annual effective dose equivalent (AEDE), the mean population weighted dose rate and cancer risk factor were calculated and found to be relative excess lifetime cancer risks were 1.280 mSv y^{-1}, 18 mSv and 1.04×10^{-3} respectively.

Key words Surface radiation dose; Annual effective dose; Cancer risk

1.0 INTRODUCTION

The great interest expressed worldwide for the study of naturally occurring radiation and environmental radioactivity has led to the interest of existence surveys in many countries. Natural sources still contribute to about 80% of the

collective radiation exposure of the world's population[1]. Human beings are continually being exposed to ionizing radiation from natural sources.

There are two main contributors to natural radiation exposures: high-energy cosmic ray particles incident on the earth's atmosphere and radioactive nuclides that originated from the earth crust and are present everywhere in the environment, including the human body[2].

Humans are exposed to radionuclides through ingestion and inhalation (internal exposure) and/or irradiation from external gamma rays emitted from the radionuclide (external exposure).

Natural environmental radioactivity and the associated external exposure due to gamma radiation depend primarily on the geological conditions[3]. The presence of naturally occurring radionuclides in the environment may result in an external and internal dose received by a population exposed to them directly and via the ingestion/inhalation pathways. The assessment of the radiological impact on a population, as result of the radiation emitted by these radionuclides, is important since they contributes to the collective dose of the population[2]. This paper tried to show the dose rate distribution and its radiological hazards in Kelantan state, Malaysia.

2.0 EXPERIMENTAL

2.1 Materials

The following materials were used in carrying out the research;

- A micro roentgen (μR) meter model 19 manufactured by Ludlum Measurement, USA.
- A Global Positioning System, Garmin (GPS Map76)
- A Geological formations and Soil types maps and ArcGIS 10.1 software

2.2 METHODS

2.2.1 Study Area

The study area is positioned in the north-east of Peninsular Malaysia, and is located on latitude $4^0 0'$- $5^0 15'$ N and longitude $101^0 15'$ - $102^0 45'$ E in the north-eastern part of the peninsula, it has a tropical climate with temperature ranges from 21 to 32 °C and intermittent rain fall throughout the year. The wet season is the east-coast monsoon season from November to January and it is situated on granites set which is undifferentiated intrusive rock [4]. The study area consists of ten (10) districts **(Figure 2.2)**. With Kota Bharu as the most populous district with a population of 491,237 inhabitants while Jeli district has the smallest population with a total number of 40,637 inhabitants, Kota Bharu is the administrative capital of the state with Kelantan River as the largest river which passes through most part of the state[5].

Figure 2.2: Districts map of the study area

2.2.2 Data Collection

The Surface radiation dose rate was measured in situ 1 meter above the ground by using Ludlum detector model 19, micro roentgen (μR) meter, manufactured by Ludlum, USA. It uses (2.54 × 2.54 cm^2) sodium iodide (NaI) crystal doped with thallium (Tl). The instrument was calibrated by Malaysian Nuclear Agency; it is a Secondary Standard Dosimetry Laboratory (SSDL). A global positioning system receiver Garmin model GPS map 76 was use for locating the latitude and longitude of each survey point [6].

The dose rates were measured from locations with different soil types **(Figure 2.3)** and geological background **(Figure 2.4)** randomly. (**Figure 3.1)** shows the external radiation survey points covering the entire study area. The results of the measurements were presented as an Isodose contour map **(Figure 3.2)** which was drawn using Arc GIS software version 10.1 and modified according to geological and soil information (from previous aerial survey), where in 1956 an Arial survey was conducted part of which was to indicate the presence of radioactive minerals in Malaya (present Malaysia). The result of the survey shows large radioactive anomalies in the study area due to presence of intrusive igneous rocks.

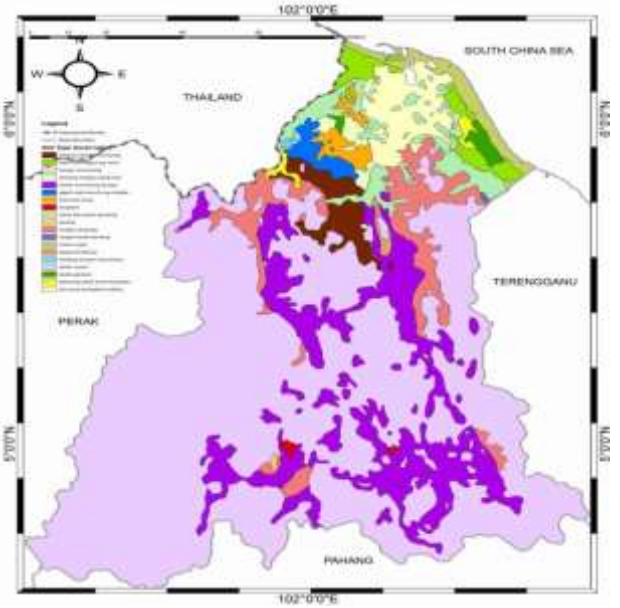

Figure 2.3: Soil types map of the study area

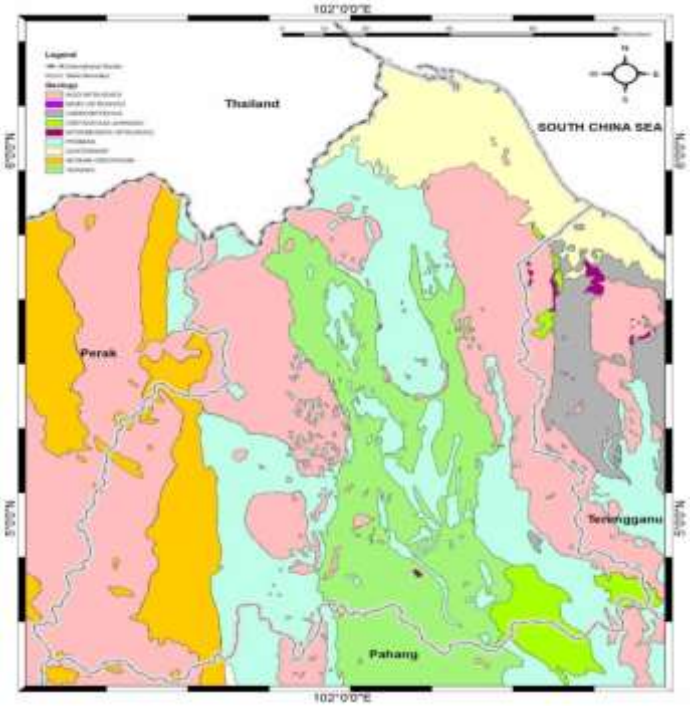

Figure 2.4: Geological map of the study area

3.0 RESULTS AND DISCUSSION

Surface radiation dose rates were measured from 150 outdoor locations, with values ranges from 44 nGy h^{-1} to 500 nGy h^{-1}, with a mean value of 176 ± 5 nGy h^{-1}. This value is three times the world and two times the Malaysian average of 59 and 92 nGy h^{-1} respectively as reported by[2]. Enhanced activity ranging between 400 to 500 nGy h^{-1} were observed in Kg. Lawang, Hutan Rizab Gunung Basab, Kg. Sg. Rual and Air Terjun Lata Hujan Gual Ipoh located in Pasir Mas, Jeli and Tanah Merah districts respectively. The highest measurement of 500 nGy h^{-1} was observed in Hutan Rizab Gunung Basab, Tanah Merah district with the lowest value of 44 nGy h^{-1} found in Kg. Bukit Kuang both in Tanah Merah district. The mean values of terrestrial gamma radiation dose rates for the ten districts are presented in Table 1.0

Table 1.0 Mean dose rate and population of each district of the study area

Districts	Dose rate (nGy h^{-1})			
	Mean	Std. Deviation	Std. Error	Population ($\times 10^3$)
Kota Bahru	184	36	13	491
Bachok	165	31	12	189
Gua Musang	184	86	14	154
Jeli	301	87	20	133
Kuala Krai	201	81	17	121
Machang	177	61	22	117
Tanah Merah	234	120	22	109
Pasir Puteh	170	65	27	93
Tumpat	117	46	27	90
Pasir mas	193	112	43	41
Total	**209**	**96**	**8**	**1540**

It could be observed **(Figure 3.3)** Jeli districts recorded the highest mean TGRD dose rates value of 301 ± 19 nGy h^{-1} which is about five times the world average, while Tumpat district has the lowest TGRD Dose rate of 117 ± 26 nGy h^{-1} and is approximately two times the world average.

The highest mean TGR dose rate value recorded is due to acid intrusive geological feature found in the areas. These areas are igneous acidic and extensively intruded by granitic rocks. The granite is relatively rich in radioactive minerals[2].

Figure 3.1: Survey location points of the study area

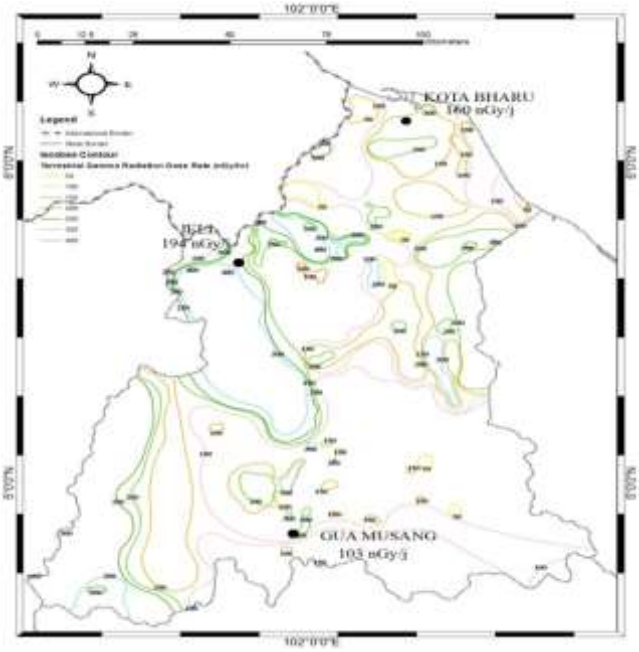

Figure 3.2: Isodose map of the study area

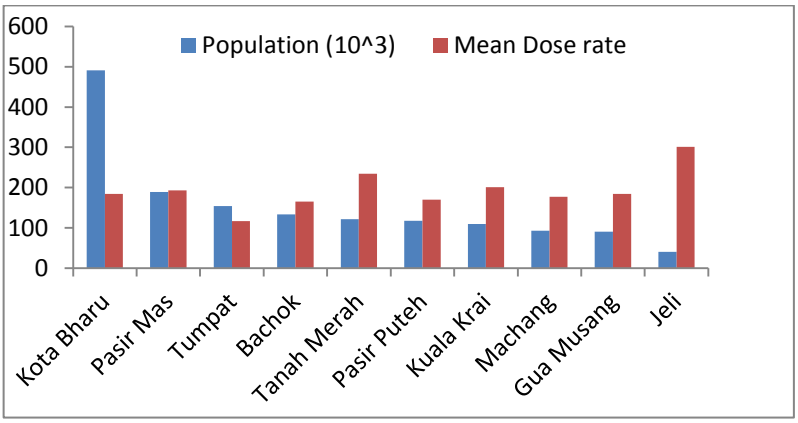

Figure 3.3: A plot of district's mean dose rate against population of the study area.

Using the conversion coefficient factor for the absorbed dose in air to effective dose of 0.7 Sv Gy^{-1}, and the outdoor occupancy factor of 0.2[2] the annual effective dose equivalent (AEDE) outdoors is calculated by using equation 1.

AEDE (mSv y^{-1}) = Dose rate (nGy h^{-1}) x 8760 hours x OF x 0.7 x 10^{-6} ---------- (1)

Where AEDE is annual effective dose equivalent in mSv, and OF is occupancy factor which is 0.2 for outdoor. The average annual effective dose equivalent outdoors received in habited areas of the study area was found to be 0.22 mSv $y.^{-1}$ this is higher than the world annual effective dose outdoor equivalent average value of 0.07 mSv y^{-1} [2]. This is not expected to contribute significant additional hazard from the radiological health point of view. The annual dose limit for members of the public according to [7] is 1 mSv y^{-1} and this limit is not applicable to doses received from natural resources.

The information on population distribution was combined with the mean gamma radiation dose rate value for each of the district to yield a population-weighted mean dose rate of the area which is 184 nGy h^{-1}. The mean population weighted dose rate, D_w was obtained from the relation in equation. (2).

$$D_W = \frac{\sum \widetilde{D} P}{\sum P} \quad \text{---------- (2)}$$

Where $\widetilde{D}$ the mean dose rate for each district and P is the corresponding population[8]. This is lower than the geographical mean dose rate which is: 176 ± 5 nGy h^{-1}. Malaysia is one of the countries that have higher than usual values of terrestrial gamma radiation dose rate [5]. The world average value is 59 nGy h^{-1} and Malaysian average value is 92 nGy h^{-1}. This higher value obtained in this study can be attributed to the geological predominance of igneous acidic intrusive granitic rocks in the study area with steep land soil type.

A comparative table consisting of the mean value of terrestrial gamma radiation dose rates in the study area, Malaysia and the world averages are presented in Table 2. It could be observed from the table that the result obtained was in good agreement with those conducted in other part of the country.

Table 2. Mean dose rates in the study area compared with the values reported from other Districts in Malaysia and world average

District/State	**Mean Dose Rate (nGy h^{-1})**	**Reference**
Kelantan	209	This study
Pahang state	176	[9]
Kinta District	222	[8]
Kota Tinggi District	180	[10]
Johor State	163	[11]
Pontian District	67a	[12]
Malaysia	92a	[2]
World	59a	[2]

[a] Average dose rate.

4.0 CONCLUSION

The mean surface radiation dose rate in the study area state was found to be about two times the Malaysian average and about three times higher than the world average value. The higher values of the surface radiation dose rate were associated with soils of granitic origin and with acid intrusive geological formation.

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